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## Tactical Situational Awareness of Enemy Gunfire

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**Introduction:** NRL has been conducting research into locating hostile gunfire based on detecting the infrared (IR) muzzle flash. As Fig. 5 shows, the IR flash is very pronounced and significantly larger than the visible flash. Recently, four integrated HMMWV-based gunfire detection and location (GDL) systems were developed under Office of Naval Research (ONR) sponsorship. GDL augmented the IR detection capability with a slewable electro-optic payload for day/night imaging, situational awareness, rangefinding, and day/night designation of hostile fire. When a gun flash is detected by GDL, the electro-optic payload sensors are automatically slewed and centered on the location of the detected gun flash. The GDL operator monitors the day/night sensor images and determines a course of action. By firing the electro-optic payload's integral laser, the operator can immediately alert others to the gun flash location. Parallel research efforts are developing improvements to the optics, the detection algorithms, networking to dismounted warfighters, IR/directional-acoustic integration, and rapid all-azimuthal capability. These efforts combine to provide for both operational experimentation and science and technology insertion to meet U.S. Marine Corps needs.

### Technical Challenges of Gunfire Detection:

Significant challenges involved in developing real-time automated detection, location, and identification of hostile gunfire include:

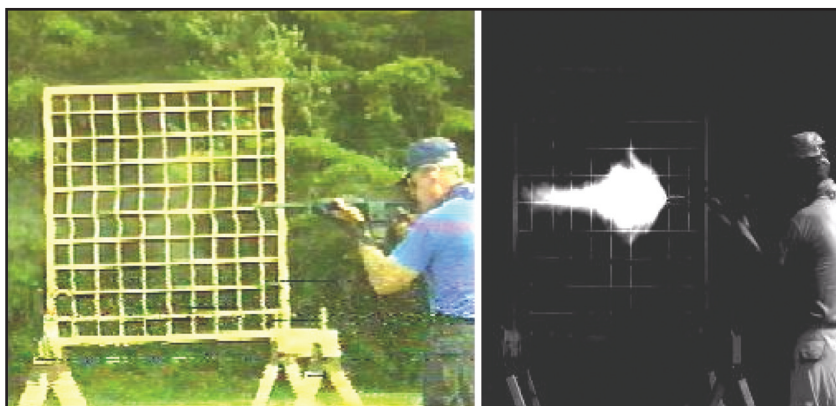
- Detecting a short-duration event,
- Rejecting natural and man-made false alarms, and
- Wide-area real-time coverage.

A key characteristic of gunflash events is their short persistence, only a few milliseconds. Consequently, detection cameras must operate with 100% stare efficiency (duty factor). Other considerations for camera selection include adaptability for spectral and temporal filtering to reduce false targets. For GDL, a commercial midwave IR (3-5  $\mu\text{m}$ ) band camera with a  $320 \times 240$  detector array was selected. For production cost reasons, larger array sizes and multispectral cameras were rejected. To improve the signal-to-noise ratio and false-alert rejection, a narrow subband filter tailored to the spectral characteristics of typical gunfire was installed in the camera.

A major challenge lay in developing automated image-processing algorithms that reliably recognize gunfire while rejecting natural and man-made clutter, such as passing cars and solar glints. Algorithm improvements extended the detection range of the earlier generation software while reducing false alarms. Field testing of the systems was used to create and expand a database (library) of various gunfire events and false-alarm sources. Algorithm improvements were tested using the database and then validated in real-time operations in subsequent testing. Compared with acoustic detection, the IR detection approach provides much greater location precision and can unambiguously handle multiple shots. However, an IR detection system integrated with an acoustic detection has provided GDL a robust way of rejecting spurious IR glint event declarations for operations in a high clutter environment. Additionally, for single-shot events, the GDL IR-acoustics combination provides passive ranging using time difference between the flash and the sound.

Another challenge has been to develop a system capable of detecting gunfire from any direction of attack. An anamorphic lens has extended the GDL instantaneous azimuth coverage to 130 deg, in contrast to the earlier generation system's 30-deg coverage. The resulting distorted image adds complexity in locating a gunshot from a particular pixel location in the camera.

**FIGURE 5**  
Imagery of gunflash in visible and infrared bands.



To overcome this distortion, a calibration process was implemented that maps the camera's detected pixel position to gimbal coordinates. This enables the electro-optical payload to be directed to the detection location.

#### **Gunfire Detection and Location (GDL) System:**

Figure 6 shows a GDL system installed on a HMMWV. The upper stage of the GDL equipment includes a slewable electro-optic payload that allows for event confirmation, precision location, and response. This payload contains a thermal camera, night-reflectance camera, visible camera, laser rangefinder, night vision laser designator, and daytime laser designator. The daytime designation problem is especially challenging because the laser required is not eyesafe. NRL developed techniques to maximize the effectiveness of the designators and reduce the laser hazard zone. Special narrowband contrast enhancement goggles and modulation techniques improve the visibility of the laser designation. Marines can locate hostile fire by looking at the laser designations or by viewing the hostile fire imagery (from the gimbaled day/night cameras) in a remote hand-held or helmet-mounted monocular device, developed at NRL. The slewable GDL electro-optic payload can also be operated in a perimeter defense mode for Marine situational awareness when not engaging hostile fire.



**FIGURE 6**  
GDL system installed on a HMMWV.

The current GDL systems were designed for U.S. Marine Corps wargaming experiments to evaluate the available technology and to establish developmental requirements.

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